

**INSTRUCTION MANUAL
FOR
IN-CIRCUIT TRANSISTOR TESTER
MODEL 1890M**

The HICKOK ELECTRICAL INSTRUMENT CO.
10514 DUPONT AVENUE • CLEVELAND 8, OHIO

TRANSISTOR TEST

OPERATING INSTRUCTIONS

1. Place function selectro switch to ICBO.
Rotate battery switch to BATT TEST, meter should read on Green portion (Good).
2. Place function selector switch to IC.
Rotate battery switch to BATT TEST, meter should read on Green portion (Good).
3. Rotate IC and BETA CAL to MIN. position.
4. Use a screwdriver on Zero Adj, Zero Meter.

IN CIRCUIT TEST (TRAN)

1. Connect the three leads to respective posts and to tran. (Yellow-Emitter, Green-Base, Blue-Coll.)
2. Set the TYPE selector switch to PNP or NPN.
3. Turn IC and BETA CAL to MIN position.
4. Set circuit IMPEDANCE switch to NORM if circuit impedance is above 500 ohms, LOW if below 500 OHMS.
5. Set collector volts switch to desired position. (TO 33A1-3-206-1, page 26D, Section I).
6. Place function selector switch to IC position and current range switch to X10. Turn batt switch to operate.
7. Observe the shunt leakage current on the 0-1 MA scale of the meter and apply its proper multiplier to determine current flow.

NOTE: Under these circumstances the meter is reading the stray leakage current flowing in the external circuitry due to the collector supply voltage.

8. Adj the collector current with IC potentiometer for one additional milliampere over the previously noted reading. If the stray leakage current is high (3,4 or 5 MA), set collector current to at least twice the noted stray leakage current.

NOTE: Power type tran should be checked with 5 or 10 MA of collector current.

CAUTION: DO NOT CHANGE CURRENT MULTIPLIERS WHILE THE TESTER IS ENERGIZED.

9. Rotate the vernier of the Z ohms potentiometer to approximately 250 ohms or MID position.

10. Place function selectro switch to the Z ohms curcuit position and turn the battery switch to the right.

11. Increase amplitude of audio osc. by turning BETA CAL. potentiometer until meter reads approximately half scale. Balance the bridge by first varying the large control of Z ohms circuit potentiometer to obtain an approx. null; ajd vernier to obtain a precise null as indicated on meter. Value of ext. input imped. can now be read directly from the calib. dials of Z ohms.

12. Place function selectro switch to RIN TRAN; turn battery switch to the right and increase amplitude of audio osc. adj RIN TRAN to balance the bridge circuit. A null will be indicated on the meter when the bridge is balanced. The value of the dynamic input resistance of the transistor is read directly from the calib. dial of the RIN TRAN potentiometer.

13. Place function selectro switch to BETA CAL. Turn battery switch to right and adj BET CAL potentiometer until meter reads one half or cal set. Then place function selectro switch to the BETA READ and read BETA directly on the meter. If the BETA of the tran. is higher than 100, recalib. metet to 1/4 scale and multiply meter reading by 2. If to high go to 1/8 scale and mult. by 4. If BETA of tran. is below 50 recalib. to full scale and read BETA directly on 0-50 scale of meter.

OUT OF CIRCUIT TEST (TRAN)

The out and in circuit tests are almost identical. The only difference is that the ICBO test is performed and the Z ohms test is omitted. When omitting the Z ohms test, the Z ohms circuit potentiometer must be switched to out of circuit position.

1. Plug tran. in socket or perform Step 1 of In Circuit Test.
2. Switch Z ohms circuit potentiometer to out of circuit position.
3. Perform Steps 2 through 5 of In Circuit Test.
4. Place function selector switch to ICBO and current range switch to X100.
5. Turn battery switch to the right and read ICBO scale on meter for leakage current. If current reading is low release battery switch and place current range switch to X10 or X1 depending on what current is measured.
6. Perform Steps 6, 7, 8, 12 and 13 of In Circuit Test.

INSTRUCTION MANUAL
FOR
IN-CIRCUIT TRANSISTOR TESTER
MODEL 1890M

THE HICKOK ELECTRICAL INSTRUMENT CO.
10514 Dupont Avenue - Cleveland 8, Ohio

STANDARD EIA GUARANTEE

The Hickok Electrical Instrument Company warrants instruments manufactured by it to be free from defective material or factory workmanship and agrees to repair such instruments which, under normal use and service, disclose the defect to be the fault of our manufacturing. Our obligation under this warranty is limited to repairing any instrument or test equipment which proves to be defective, when returned to us transportation prepaid, within 90 days from the date of original purchase, and provided the serial number has been made known to us promptly for our records.

This warranty does not apply to any of our products which have been repaired or altered by unauthorized persons or service stations in any way so as, in our judgment, to injure their stability or reliability, or which have been subject to misuse, negligence, or accident, or which have had the serial number altered, effaced or removed. Neither does this warranty apply to any of our products which have been connected, installed, or adjusted otherwise than in accordance with the instructions furnished by us. Accessories, including all vacuum tubes not of our manufacture, used with this product are not covered by this warranty.

This warranty is in lieu of all other warranties expressed or implied, and no representative or person is authorized to assume for us any other liability in connection with the sale of our products.

Parts will be made available for a minimum period of five years after the manufacture of this equipment has been discontinued. Parts include all materials, charts, instructions, diagrams, accessories, etc., which have been furnished in the standard model.

RETURNING EQUIPMENT FOR REPAIR

Before returning any equipment for service, under warranty or otherwise, the factory must first be contacted giving the nature of the trouble. Instructions will then be given for either correcting the trouble or returning the equipment. Upon authorization, this equipment should be forwarded directly to the Hickok factory address, 10636 Leuer Avenue, Cleveland, Ohio, or to a designated service station in your locality. All correspondence pertaining to repairs should be directed to the Hickok office address, 10514 Dupont Avenue, Cleveland 8, Ohio, or to the authorized service station designated.

REGISTRATION CARD

The above guarantee is contingent upon the attached registration card being returned to the factory immediately upon receipt of the equipment.

THE HICKOK ELECTRICAL INSTRUMENT COMPANY
Cleveland, Ohio

INTRODUCTION

1. General

This manual contains instructions for the installation, operation, maintenance and repair of the Model 1890. In addition to these instructions, the theory of operation covering the electrical components is included. A complete schematic diagram of the individual components of the unit appears in the rear of the manual. In addition to the complete schematic, there are simplified schematics which show the individual test circuits throughout the manual.

2. Purpose and Features

The Hickok Model 1890, Dynamic Beta "In Circuit Transistor Tester" is designed to test all small and medium power transistors directly in their circuits. The unique features of this instrument are the following:

- a. The Dynamic Beta is read directly on the meter.
- b. The external Input Impedance of the transistor circuit is read directly from the carefully calibrated potentiometers.
- c. The Dynamic Input Resistance of the transistor is read from another carefully calibrated potentiometer.
- d. The collector cutoff current I_{CBO} can be read directly on the meter. For this test the transistor must be removed from the circuit.
- e. The collector current I_C is read directly on the meter.
- f. Diodes can also be tested for their dynamic input impedance for both the "In Circuit" and "Out of Circuit" test conditions.
- g. The tester can also be used for "Out of Circuit" transistor tests.

BATTERY INSTALLATION

MODEL 1890M

Normally the Model 1890M In-Circuit Transistor Tester is not supplied with batteries. This is due to the fact that batteries deteriorate with age. Therefore the following complement of batteries should be installed.

- 2 - No. 2370 ST Burgéss
1 - No. 4156 Burgess or 763 Eveready

The procedure for the installation of the batteries is the following:

1. Remove the ten panel screws which are located near the outer edge of the panel.
2. Gently lift the panel assembly out of its case and disconnect the cable assembly from the chassis.
3. Remove the eight screws that hold the battery brackets to the case.
4. Place the smaller of the two brackets around battery #1 and the other bracket around batteries #2 and #3. See Figure 1. NOTE: When installing the batteries in their brackets, there should be sufficient clearance between the lip of the brackets and the battery studs.
5. Place the battery assemblies in the case and secure them to the case with the eight screws that were removed.
6. Then connect the various leads to their proper batteries. The wires are color-coded for easy recognition and are soldered to lugs for ease of installation. Figure 1 lists the color of the leads and shows where they should be placed. Tighten each lug securely to its stud.
7. Reconnect the cable assembly to the chassis.
8. In order to check the 22.5 volt battery in the unit, place the Function Selector Switch to the ICBO position and turn the BATT TEST-OFF-OPERATE switch to the BATT. TEST position. If the battery is good and properly connected, the meter will read in the green portion of the battery test scale. To check the two 4.5 volt batteries, place the Function Selector Switch to the IC position and turn the BATT TEST-OFF-OPERATE switch to the BATT TEST position. If the batteries are good and properly connected the meter will read in the green portion of the battery test scale. In addition to the two battery tests, the following DC voltage measurements should be made at the three binding posts of the tester. Table I shows where the various switches should be placed and what voltages are to be read at the binding posts of E-C, E-B and B-C. The plus lead of the DC Voltmeter is indicated by a + sign over the pair of binding posts being measured. However, only Row I, Column Ic of Table I must be measured.
9. Then place the panel assembly back into its case and secure it with the ten screws that were removed.

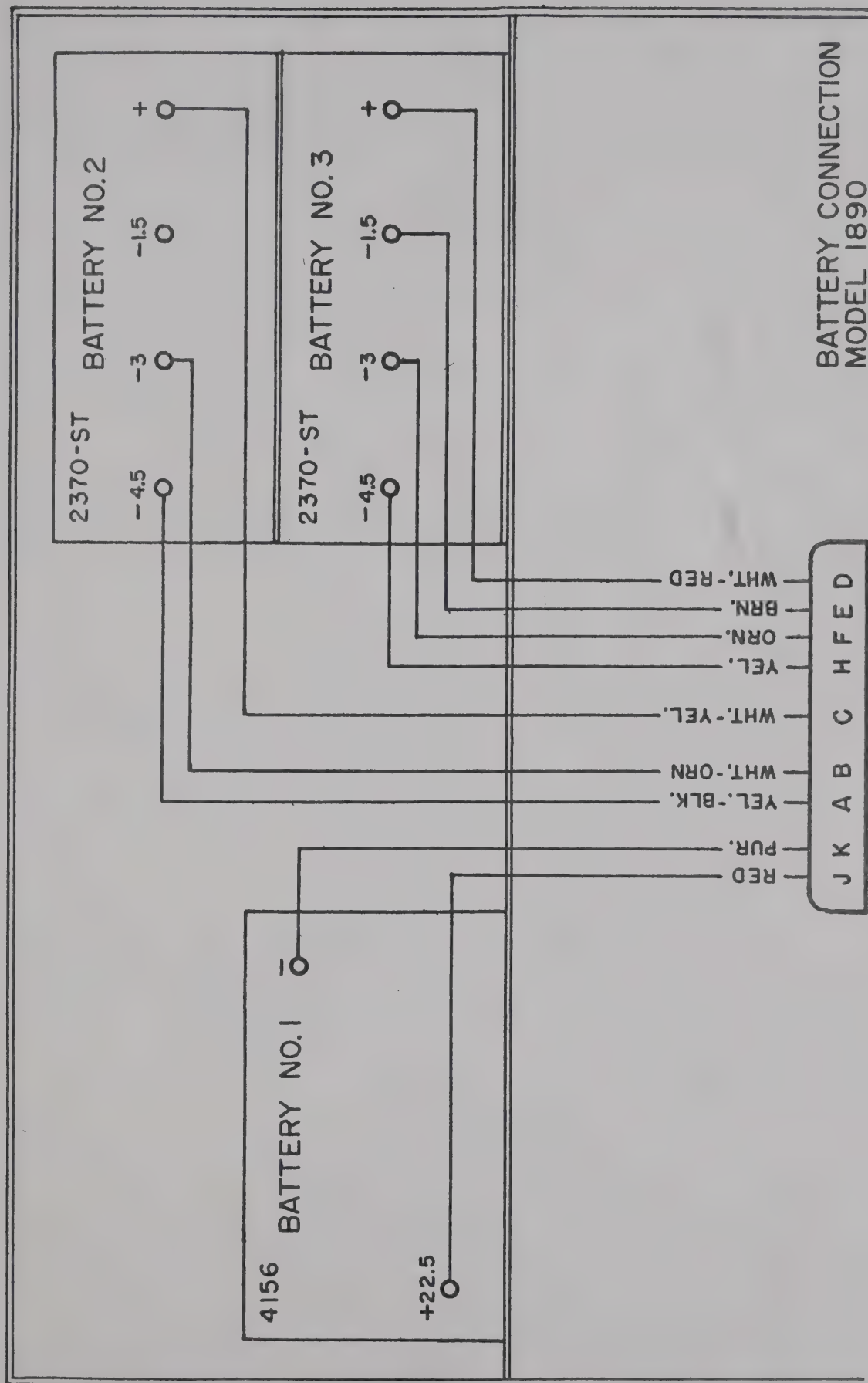


Figure 1.

3. Technical Data

a. Batteries required

- 1 - 22.5 volt No. 763 Eveready or No. 4156 Burgess
- 2 - 4.5 volt No. 2370 ST Burgess

b. Meter Scales

ICBO Ranges - 0-50 μ a, 0-500 μ a and 0-5 ma
IC Ranges - 0-1.0 ma, 0-10 ma and 0-100 ma
Beta Ranges - 0-50, 0-100, 0-200 and 0-400
Beta Test Accuracy - $\pm 5\%$ for Circuit Impedances above 25 ohms on the 0-100 Beta range

c. Meter

Sensitivity - 50 μ a, 100 MV

d. AC Test Signal

1000 cps sine wave, with a variable amplitude
Calibration setting - 5 μ a Base Current for the 0-100 Beta Range

e. Transistor Input Resistance Range

50-10,000 ohms

f. Circuit INPUT Impedance Range

25-100,000 ohms

g. Collector Voltages

0, 1.5V, 3V and 4.5V

h. Transistor Complement:

	<u>Type</u>	<u>Function</u>
Q1, Q2	2N651A	1000 cps Oscillator
Q3	2N650A	A. C. Meter Amplifier - 1st Stage
Q4, Q5	2N651A	A. C. Meter Amplifier - 2nd Stage and 3rd Stage

THEORY OF OPERATION

A. General Information

There are a few basic definitions which should be restated in order to help the operator of this instrument obtain its maximum usability.

1. Beta is the forward current transfer ratio of a transistor in the common emitter configuration,

$$\frac{\Delta I_C}{\Delta I_B} = B = \text{Beta}$$

2. Alpha is the forward current transfer ratio of a transistor in the common base configuration,

$$\frac{\Delta I_C}{\Delta I_E} = a = \text{Alpha}$$

3. The relationship between Alpha and Beta is established by the following formula,

$$\text{Beta} = \frac{\text{Alpha}}{1 - \text{Alpha}}$$

$$\text{Alpha} = \frac{\text{Beta}}{1 + \text{Beta}}$$

If either of these parameters (Alpha or Beta) is known, the other may be found by applying the proper formula.

4. Figure 2 shows a "model transistor" connected as a common emitter amplifier. This model transistor amplifier neglects the effects of r_c , the ohmic resistance of the collector junction. From this figure the input resistance is seen to be

$$R_{IN} = r_b + \frac{r_e}{1 - a}$$

and the approximate voltage gain is,

$$\frac{e_2}{e_1} = \frac{a R_L}{r_b (1 - a) + r_e} = \frac{a R_L}{(1 - a) R_{IN}} = B \frac{R_L}{R_{IN}}$$

From the above formula the significance of the measurement of R_{IN} can be appreciated.

B. Theory of Operation for the Transistor Tests

A thorough understanding of the theory behind the operation of any instrument will enable the operator to obtain greater utility and satisfaction from the instrument. For this reason a brief description of the principal circuits of the instrument and diagrams of the basic test circuits are given.

The instrument has six basic sections: (1) Battery Supplies, (2) Audio Oscillator, (3) Variable Resistance Bridge, (4) AC Voltmeter, (5) Type Selector Switch and (6) Function Selector Switch.

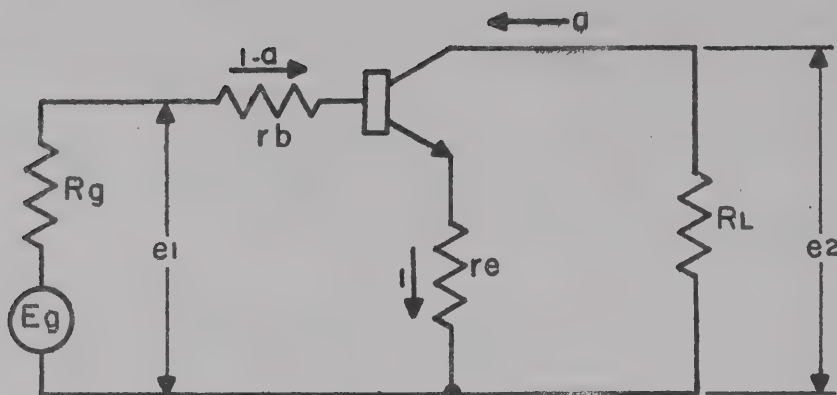


Figure 2.

1. Battery Supplies

- a. The internal power requirements of the audio oscillator, the A.C. Amplifier and meter circuit are supplied by a 22.5 volt battery.
- b. The collector voltage for the transistor under test is obtained from a tapped 4.5 volt battery. The collector voltage can be varied from 0 to 4.5 volts in 1.5 volt steps by changing the position of the COLLECTOR VOLTS switch.
- c. The collector current can be varied from 0 - 1 ma, 0 - 10 ma and 0 - 100 ma, depending upon external circuitry conditions, by varying the current into the base of the transistor under test. This is accomplished by using a potentiometer, I_C , across a 1.5V battery, when the Circuit Impedance Switch is in the NORMAL position, and across a 4.5V battery when the Circuit Impedance Switch is in the LOW position. This arrangement gives a variable biasing network for the base to emitter circuit of the transistor under test.

2. Audio Oscillator

A 1000 cps Colpitts Oscillator consisting of a tuned circuit, transistor, and its associated biasing and feedback networks, is used to generate the A.C. test signal. The output of the oscillator is A.C. coupled into an emitter follower, whose output is then coupled into a step-down transformer by means of the Beta Cal potentiometer located in the emitter circuit of the amplifier. The output of the step-down transformer is connected to the variable resistance bridge through the FUNCTION SELECTOR switch. The amplitude of the test signal is controlled by the Beta Cal potentiometer.

3. Variable Resistance Bridge

- a. One leg of the bridge circuit is the base to emitter input impedance of the transistor under test. This input impedance can be the parallel combination of the external circuitry impedance of the transistor under test and its dynamic input resistance. The balancing leg consists of one dual potentiometer, Z OHM circuit, and a single potentiometer, R_{IN} Transistor, which is connected in parallel with the dual potentiometer in the last three positions of the FUNCTION SELECTOR switch.

The dual potentiometer is used to null out the external circuit impedance of the transistor under test. If an "Out of Circuit" test is performed, this dual potentiometer must be removed from the circuit. A SPST switch is provided to

accomplish this condition. The single potentiometer, R_{IN} TRANSISTOR is used to null out the dynamic input resistance of the transistor.

b. Low-Normal Circuit Impedance Switch

The functions of this switch are to change the circuit constants in the bridge and also to change the applied battery voltages to the forward biasing network which is used to adjust the collector current of the transistor under test. In the LOW position, the circuit constants are given low resistance values in order to present a low driving impedance to the external circuitry and transistor under test. However, in the NORMAL position, the circuit constants are given nominal values, thus presenting a normal driving impedance to the external circuitry and transistor under test.

The setting of the LOW-NORMAL Circuit Impedance Switch will depend upon the impedance of the external circuitry and transistor under test.

In transistor power amplifiers where the external circuitry and transistor impedances are normally LOW or in any circuit where the impedance is under 500 ohms the LOW position of the switch should be selected.

In small signal RF-IF and Audio amplifiers where the external circuitry and transistor impedances are above 500 ohms the NORMAL position should be selected.

When estimating the external circuit impedance at 1000 cps, only the circuitry between the Base and Emitter should be considered. If there is any doubt as to which position to use, the NORMAL position should be selected.

CAUTION: In either position of the CIRCUIT IMPEDANCE Switch, the operator must test the transistor below its maximum collector dissipation.

4. A.C. Voltmeter

The A.C. Voltmeter Circuit consists of a three-stage amplifier which is highly degenerative to provide excellent stability, and a crystal diode bridge detector. The input sensitivity of the amplifier is .5 MV P-P or .176 MV RMS for full scale deflection of the meter.

5. Type Selector Switch

The Type Selector switch is a three position switch which changes the polarity of the applied voltages to the transistor or diode under test. The three positions of the switch are PNP, NPN and DIODE. The position of the switch is determined by the circuit element to be tested -- that is, an NPN or PNP transistor, or a diode.

6. Battery Test - OFF-OPERATE switch

This switch is a three position, momentary contact, center OFF spring return in both directions -- that is, to the left and right. The switch always returns to the center position after it has been released.

The tester and its associated circuitry for testing a transistor is energized in the OPERATE position of the switch. The BATT. TEST position of this switch will be explained in conjunction with the FUNCTION SELECTOR switch, because they are interrelated.

7. The FUNCTION SELECTOR switch is a six-position switch which sets up the internal circuitry to perform the various indicated tests. These tests are:

- (1) I_{CBO}
- (2) BATT TEST #1

- (1) I_C
- (2) BATT TEST #2

- (1) Z Ohms Circuit

- (1) R_{IN} TRANSISTOR

- (1) Beta Cal

- (1) Beta

a. (1) I_{CBO} TEST

In the I_{CBO} test, a reverse voltage is applied across the collector-base diode of the transistor. The emitter is open-circuited. NOTE: The transistor must be removed from its circuit for this test. The collector cutoff current is read directly on the 0-50 μa scale of the meter and the appropriate multiplier should be used -- that is, X1, X10 or X100. The meter is connected in series with a limiting resistor to the applied voltage and the transistor under test. The circuit is shown in Figure 3.

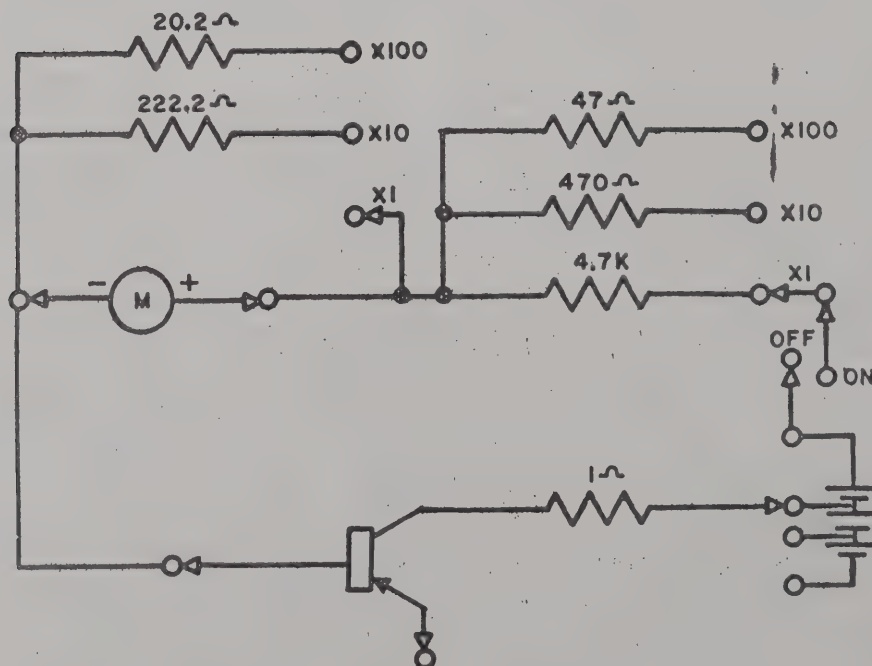


Figure 3. I_{CBO} Test Circuit

By placing the BATT-TEST-OFF-OPERATE switch to the BATT TEST position, the tester and its associated circuitry is de-energized and the 22.5 volt battery is tested under a fixed load of 3.3K. The quality of the battery is read from the meter scale, which is in two colors, red and green. The red portion of the scale indicates that the battery is low, while the green portion of the scale indicates that the battery is good.

The IC control adjustment is made in the following manner when testing transistors in circuit: Set the IC potentiometer to "zero" or its minimum position. Note the shunt leakage current on the 0-1.0 ma scale of the meter and the appropriate multiplier should be used -- that is, X1, X10 or X100. Under these circumstances the meter is reading the stray leakage current flowing in the external circuitry due to the collector supply voltage. Now adjust the IC potentiometer for one additional milliampere over the previously noted reading. With this setting one milliampere of collector current will flow through the transistor which is considered standard for a small signal beta test. If a larger collector current is desired, the IC potentiometer can be adjusted to the desired value. Figure 4 shows the circuitry used to perform this test; it does not include the external circuitry of the transistor.



(2) BATT TEST #2

When the BATTERY TEST-OFF-OPERATE switch is placed in the BATT TEST position, the quality of the two 4.5V batteries is determined by reading the dual colored scale of the meter. If the pointer of the meter is in the red portion of the scale the batteries are low, and if it is in the green portion of the scale the batteries are good.

c. Z Ohms Circuit (external input circuit impedance)

In order to determine the Z input circuit impedance, it is necessary to separate the external input circuit impedance from the transistor input resistance. This is accomplished by reversing the bias on the transistor so that it is cut off, thus separating the external input circuit impedance from the transistor input resistance.

The external input circuit impedance forms one leg of the bridge circuit and its value is determined by varying the "Z" Ohms Circuit potentiometers until a null is indicated on the sensitive AC voltmeter tied across the bridge. The value of this external input circuit impedance can be read directly from the calibrated dials of the Z Ohms Circuit potentiometers. This null should be made very carefully because it can affect the next test, which is the R_{IN} of the transistor.

If the transistor is Out of Circuit the external input impedance is almost infinite. Therefore the Z Ohm potentiometers must be removed from the bridge circuit. This is accomplished with a SPST switch which is ganged to the shaft of the small knob of the Z Ohms potentiometer. The switch must be placed to the "Out of Circuit" position in order to remove the Z Ohm potentiometers from the bridge circuit. Figure 5 shows the circuit for the above test.

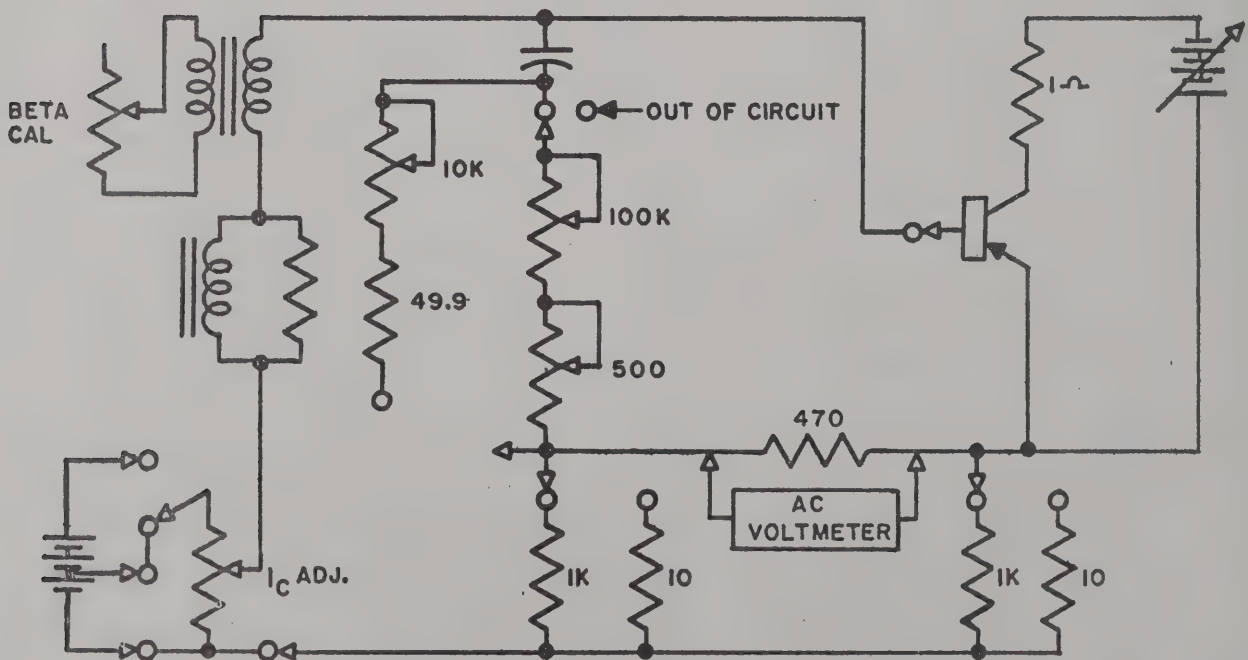


Figure 5. Z Ohms Test Circuit

d. R_{IN} TRANSISTOR

The dynamic input resistance of the transistor can now be determined by using the same technique used in determining the external input circuit impedance. However, in this test the transistor is biased in the forward direction, and the previous settings of the "Z Ohms Circuit" potentiometers are retained. The value of the dynamic input resistance is determined by varying the R_{IN} TRANSISTOR potentiometer until a null is indicated on the meter. The value of the dynamic input resistance can be read directly from the calibrated dial of the R_{IN} TRANSISTOR potentiometer. The circuit diagram for this test is shown in Figure 6.

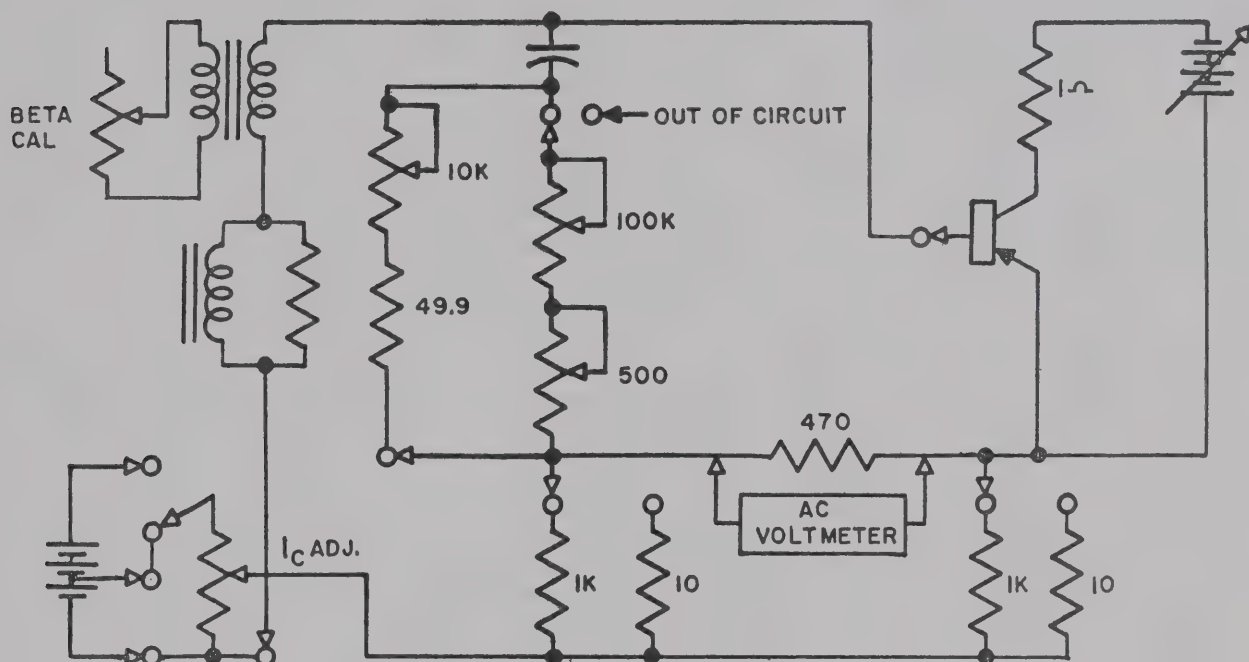


Figure 6. R_{IN} Test Circuit

e. BETA CAL and BETA

and

f. A.C. Beta is the current gain of a transistor in the common emitter configuration and is defined as the ratio of the A.C. collector current to the A.C. base current

$$\frac{i_c}{i_b}$$

In order to measure both of these currents, it was necessary to place a monitoring resistor of 50 ohms in the bridge circuit and another monitoring resistor of 1 ohm in the collector circuit. Then using the sensitive A.C. Voltmeter to monitor the voltage drops across these resistors, the A.C. Beta can be determined. Placing the FUNCTION SELECTOR switch to the Beta Cal position, the A.C. Voltmeter monitors the voltage drop across the 50 ohm resistor, then the Beta Cal potentiometer is adjusted until the meter reads 1/2 scale or Cal Set. Under this condition there is 5 μ a of current flowing in the base circuit. The FUNCTION SELECTOR switch is then placed to the Beta position. This switches the AC Voltmeter across the 1 ohm monitoring resistor and the volt-

meter reads beta directly. The circuit diagrams for these tests are the same as that shown in Figure 6 with the exception of the location of the AC Voltmeter.

C. Theory of Operation for the Diode Tests

The circuitry used to perform the Diode Tests is essentially the same as that used for the Transistor tests. The only difference between the circuitry is the functions performed by the Type Selector switch. This switch performs three different functions, the first of which is to reverse the meter in the IC position of the Function Selector switch, so that the total current drawn by the diode and its external circuitry can be measured. Secondly it shorts out the current limiting resistors in the collector circuit, which are used to protect the meter if a shorted transistor is tested and lastly it removes the Collector Voltage supply in the last 5 positions of the Function Selector switch. Figure 7 shows the circuit used for the IC test. It should be compared to Figure 4 and the differences noted.

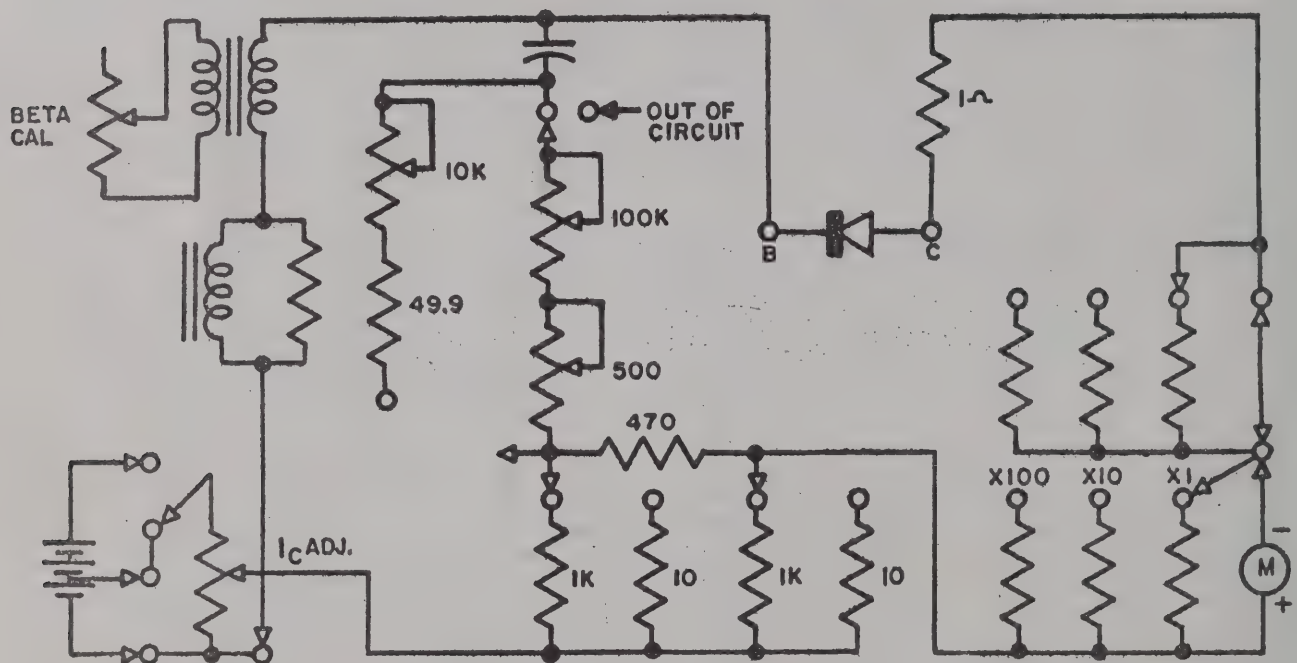


Figure 7. Diode Test Circuit

OPERATING INSTRUCTIONS

For the purpose of quick reference, the bottom views of the most common types of transistors are shown in Figure 8.

Before testing any transistor it is recommended that the manufacturer's specification sheets or the transistor reference chart be consulted. The tests performed by the Model 1890 In-Circuit Transistor Tester are I_{CBO} , I_C , Z Ohms, R_{IN} and Beta. However, when testing a transistor for its collector leakage current, I_{CBO} , the transistor must be removed from its external circuitry. These tests must be performed carefully and in a proper sequence.

Before attempting to test any transistor or diode, make sure that the I_C and Beta Cal potentiometers are turned to 0 or to their minimum positions. This will prevent any possible damage to the transistor or diode to be tested. The test procedure will be separated into the following categories -- "In Circuit" transistor tests, "Out of Circuit" transistor tests, "In Circuit" diode tests, "Out of Circuit" diode tests and additional tests.

A. The test procedure for the "In Circuit" transistor test is as follows:

1. Connect the three colored banana plugs of the test lead to their respective binding posts located on the tester. Then connect the other end of the test leads to the transistor to be tested. The yellow lead is connected to the emitter, the green lead to the base and the blue lead to the collector.
2. Set the TYPE SELECTOR switch to either the PNP or the NPN position, depending upon which type of transistor is to be tested.
3. Before attempting to test any transistor, make sure that the I_C and Beta Cal potentiometers are turned to "zero" or their minimum positions.
4. Set Circuit Impedance Selector to NORMAL if circuit impedance is above 500 ohms or to LOW if circuit impedance is below 500 ohms.
5. Select the collector voltage desired for testing the transistor: 0-4.5 volts in 1.5 volt steps, usually 1.5 volts.
6. Place the FUNCTION SELECTOR switch to the I_C position and its multiplier to the X10 position. Turn the OPERATE switch to the right. This energizes the tester.
7. Observe the shunt leakage current on the 0-1 MA scale of the meter and apply its proper multiplier in order to determine the current flowing.

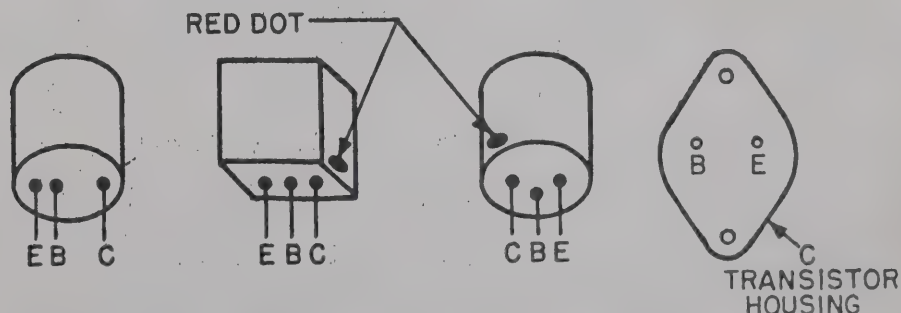


Figure 8. Transistor Lead Identification

Under these circumstances the meter is reading the stray leakage current flowing in the external circuitry due to the collector supply voltage. Now adjust the collector current with IC potentiometer for one additional milliampere over the previously noted reading. If the stray leakage current is high, 3, 4 or 5 MA, set the collector current to at least twice the noted stray leakage current, by adjusting the IC potentiometer.

NOTE: Power types of transistors, which are used in the final audio output stages of transistor radios, should be checked with 5 or 10 MA of collector current.

NOTE: DO NOT CHANGE CURRENT MULTIPLIERS WHILE THE TESTER IS ENERGIZED.

8. Rotate the vernier of the Z Ohm potentiometer to approximately 250 Ohms, or mid position.
9. Place the Function Selector Switch to the Z Ohms Circuit position and turn the Operate switch to the right.
10. Increase the amplitude of the audio oscillator by turning the Beta Cal potentiometer until the meter reads approximately half scale, and then balance the bridge by varying first the large control of the Z ohm Circuit potentiometer in order to obtain an approximate null. The vernier then should be used to obtain a precise null. The null will be indicated on the meter. The value of the external input impedance can now be read directly from the calibrated dials of the Z Ohm Circuit potentiometers.
11. Place the FUNCTION SELECTOR switch to the R_{IN} TRANSISTOR position, turn the operate switch to the right and increase the amplitude of the audio oscillator, then by varying the R_{IN} potentiometer, balance the bridge circuit. A null will be indicated on the meter when the bridge is balanced. The value of the dynamic input resistance of the transistor is read directly from the calibrated dial of the R_{IN} Potentiometer.
12. Place the FUNCTION SELECTOR switch to the Beta Cal position. Turn the Operate switch to the right and adjust the Beta Cal potentiometer until the meter reads 1/2 scale or Cal Set. Then place the FUNCTION SELECTOR switch to the Beta position and read Beta directly on the meter. If the Beta of the transistor is higher than 100, recalibrate the meter to 1/4 scale and then multiply the meter reading by 2. If the Beta of the transistor is higher than 200, recalibrate the meter to 1/8 scale and multiply the meter reading by 4. If the beta of the transistor is below 50, and an accurate value of Beta is required, recalibrate the meter to full scale and read Beta directly on the 0-50 scale of the meter.

B. "Out of Circuit" Transistor Tests

The test procedure for the "Out of Circuit" test condition is almost identical to that of the "In Circuit" test procedure. The only difference is that the ICBO test is performed and the Z Ohms Circuit test is omitted. When omitting the "Z Ohms Circuit" test, the Z Ohm Circuit potentiometer must be switch to the "Out of Circuit" position.

1. ICBO Test (Collector Leakage Current)

The test procedure is the same as that stated in Operating Instructions, Section A, paragraphs 1 thru 5. The FUNCTION SELECTOR is placed to the ICBO position and ICBO multiplier to the X100 position. Turn the Operate Switch to the right and the leakage current is read on the ICBO scale of the meter. If the current reading is low, release the Operate Switch and then change the meter multiplier to the X10 or X1 position, depending upon what current is measured. The other tests are exactly the same as stated for the "In Circuit" test condition.

Example of an Out of Circuit test for a 2N1376:

- a. Place the transistor in socket provided on the unit.
- b. Place the Type Selector to the PNP position.
- c. Place the Collector Volts switch to 1.5 volts.
- d. Place the Z ohm circuit potentiometer switch to the Out of Circuit position.
- e. Set Circuit Impedance to Normal.
- f. Place the FUNCTION SELECTOR switch to the ICBO position and the ICBO multiplier to the X1 position. Then turn the operate switch to the right. Read the 0-50 μ a scale of the meter. A typical reading is 3.5 μ a, then release the operate switch.
- g. Place the FUNCTION SELECTOR switch to the IC position and the IC multiplier to the X1 position. Then turn the Operate Switch to the right, and using the IC control, set the collector current to 1 ma. Then release the Operate Switch.
- h. Place the FUNCTION SELECTOR switch to the R_{IN} TRANSISTOR position and turn the Operate Switch to the right. Adjust the Beta Cal potentiometer until the meter reads approximately 1/2 scale, then vary the R_{IN} potentiometer until a null is obtained and then release the Operate Switch. A typical value for R_{IN} is about 2000 ohms.
- i. Place the FUNCTION SELECTOR switch to the Beta Cal position and turn the Operate Switch to the right. Adjust the Beta Cal potentiometer until the meter reads 1/2 scale or Cal Set. Then turn the FUNCTION SELECTOR switch to the Beta position and read Beta on the 0-100 scale of the meter. A typical value is 95.

DIODE TESTS

C. The test procedure for the "In Circuit" Diode Test is the following:

1. Connect the three colored banana plugs of the test lead to their respective colored binding posts on the tester. Then connect the other end of the test leads to the diode to be tested in this manner: the green lead is connected to the cathode end, the blue lead to the anode end and the yellow lead is left open-circuited.
2. Set the TYPE SELECTOR switch to the DIODE position, and also set the I_C and Beta Cal potentiometers to their minimum positions.
3. Place the CIRCUIT IMPEDANCE switch to LOW or NORMAL, depending on circuit impedance, and also the I_{CBO} and I_C current switch to the X10 position.
4. The setting of the Collector Volts switch is immaterial in this test because this supply is not used in an "In Circuit Diode Test".
5. Place the FUNCTION SELECTOR switch to the I_C position, and turn the OPERATE switch to the right. This energizes the unit.
6. Adjust the I_C potentiometer until the meter reads .1 MA. Under this condition the meter is actually reading 1 MA.
7. Turn the FUNCTION SELECTOR switch to the Z OHM circuit position and increase the amplitude of the audio oscillator by turning the Beta Cal potentiometer until the meter reads half scale. Then vary the Z OHM circuit potentiometers until a null is obtained on the meter. Then read the value of the external impedance from the calibrated dial of the Z OHM circuit potentiometers. If the null occurs near zero or some low value, the diode can be assumed to be shorted or leaky.
8. Then place the FUNCTION SELECTOR switch to the R_{IN} TRANSISTOR position and increase the amplitude of the audio oscillator until the meter reads half scale. Then balance the bridge by varying R_{IN} TRANSISTOR potentiometer until a null is indicated on the meter. The value of the diode's dynamic forward resistance can be read from the dial of the R_{IN} potentiometer. Normal values of 50-500 ohms can be expected. If a high value of resistance is obtained, the diode can be assumed to be open circuited or the external circuitry which shunts the diode is extremely low. If the external circuitry is low, adjust the I_C Potentiometer until the meter reads 2 to 5 MA and then null the diode's dynamic resistance. The variations in the dynamic forward resistance of a diode is a function of the DC current flowing through the diode.

D. The test procedure for the "Out of Circuit" Diode Test is the following:

1. Connect the three colored banana plugs of the test lead to their respective colored binding posts on the tester. Then connect the other end of the test leads to the diode to be tested in this manner: the green lead is connected to the cathode end, the blue lead to the anode end and the yellow lead is left open circuited.
2. Set the TYPE SELECTOR switch to the DIODE position and also set the I_C and Beta Cal potentiometers to their minimum position.
3. Place the CIRCUIT IMPEDANCE switch to the NORMAL position, and also the I_{CBO} and I_C current switch to the X10 position.

4. Set the COLLECTOR VOLTS switch to the 1.5V position.
5. Place the FUNCTION SELECTOR switch to the ICBO position and turn the Operate Switch to the right. Now read the leakage current of the diode on the meter, then release the Operate Switch.

If the meter reading is high the diode is shorted or very leaky.

6. Place the FUNCTION SELECTOR switch to the IC position and turn the Operate Switch to the right. Adjust the IC potentiometer until the meter reads .1 MA. Under this condition the meter is actually reading 1 MA.
7. Place the Z OHM circuit potentiometers to their "Out of Circuit" position and then omit the Z OHM circuit test.
8. Place the FUNCTION SELECTOR switch to the R_{IN} TRANSISTOR position and turn the Operate Switch to the right. Increase the amplitude of the audio oscillator by varying the Beta Cal potentiometer until the meter reads half scale. Then balance the bridge by varying the R_{IN} potentiometer until a null is indicated on the meter. The value of the diode's dynamic forward resistance can be read from the dial of the R_{IN} potentiometer. Figure 7 shows the circuit diagrams for the diode tests.

ADDITIONAL TESTS

E. The Model 1890 can also perform the following tests:

1. ICEO TEST (for small signal types) "Out of Circuit"

By definition, ICEO is the collector leakage current with the collector reverse-biased and the base open-circuited. In general the ICEO leakage current is considerably larger than ICBO. The test is performed in the following manner.

- a. Place the TYPE SELECTOR to either the NPN or the PNP position, depending upon the type of transistor.
- b. Place the COLLECTOR VOLT switch to the 1.5V position.
- c. Place the FUNCTION SELECTOR switch to the ICBO position.
- d. Connect the collector to the blue lead and the emitter to the green lead of the cable assembly and leave the base open-circuited.
- e. Place the ICBO multiplier switch to the X100 position and then turn the Operate Switch to the right. Read the leakage current on the 0-50 μ A scale of the meter. If the reading is low, place the ICBO multiplier switch to the X10 or X1 position, depending upon how much leakage current is being measured.

2. IEBO TEST (for small signal types) "Out of Circuit"

By definition, IEBO is the emitter leakage current with reverse-bias applied to the emitter and the collector open circuited. The test is as follows:

- a. Place the Type Selector to either the NPN or the PNP position.

C - BLU E - GRN
B - GRN E - BLU

- b. Place the Collector Volts switch to the 1.5V position.
- c. Place the FUNCTION SELECTOR switch to the ICBO position.
- d. Connect the base to the green lead, the emitter to the blue lead of the cable assembly and the collector is left open-circuited.
- e. Place the ICBO multiplier switch to the X100 position and then turn the Operate Switch to the right. Read the leakage current on the 0-50 μ a scale of the meter. If the reading is low, place the ICBO multiplier switch to the X10 or X1 position depending upon how much leakage current is being measured. However, release the Operate Switch when changing current multipliers.

3. Determining the impedance ratio of an Audio Transformer:

The impedance ratio of an audio transformer can be determined in the following manner:

- a. Connect the primary of the transformer to the yellow and green leads of the cable assembly.
- b. Place the IC control to its minimum position.
- c. Place the FUNCTION SELECTOR switch to the Z Ohms position and be sure that the Z Ohms potentiometers are in the circuit.
- d. Place a resistive load across the secondary.
- e. Turn the Operate Switch to the right and increase the Beta Cal potentiometer until the meter reads full scale. Then vary the Z OHM potentiometers until a null is indicated on the meter. Release the Operate Switch. Read the value of reflected impedance from the dial of the Z ohms potentiometer. Knowing the reflected impedance and the secondary load, the impedance ratio can be determined. Also, knowing the impedance ratio the turns ratio can also be determined. The turns ratio is the square root of the impedance ratio. The formula is

$$TR = \sqrt{\frac{Z_p}{Z_s}}$$

TRANSISTOR REFERENCE CHART

- F. The Transistor Reference Chart was incorporated in this manual as an aid in evaluating the quality of transistors tested. It also contains a cross reference of American-made transistors to foreign-made transistors. In order to explain the use of the Transistor Reference Chart each column of the chart will be explained separately.

TYPE

This column specifies the type of transistor, that is, an NPN or a PNP. The type selector switch should be set accordingly.

MAX ICBO

This column specifies the maximum allowable leakage current. If the leakage current of the transistor under test exceeds this value it can be considered out of tolerance or defective. The collector voltage used for this test should be 4.5 volts. However, this test must be performed "Out of Circuit".

VCE

This is the Collector to Emitter voltage specified for the Beta test, "In or Out of Circuit". The Collector Volts switch should be set accordingly.

IC

This column specifies the collector current in milliamperes for the test. The Beta Test should be made at or near this level. The IC control adjusts the amount of forward bias and the current can be read on the meter when the Function Selector switch is in IC position. This preliminary adjustment must be made for both the "In and Out of Circuit" tests.

BETA

Beta values are given in three columns -- Minimum, Typical and Maximum. In some cases only Typical values are listed. This is due to the fact that the Transistor Manufacturer only lists the Typical value in his specification sheets.

NOTES

Notes 1 thru 8 are listed in the beginning of the Transistor Reference Chart. These notes are self-explanatory and used in specific cases where deviation from conventional test procedure is required.

G. Conclusions from the Tests performed:

For your convenience the Transistor Reference Chart was incorporated in this manual. It is to be used only as a guide in evaluating the quality of transistors tested. In order to simplify the Chart as much as possible, only the pertinent information necessary for testing a transistor was given. For any additional information the transistor manufacturer's literature should be consulted. The test results should be within the limits specified in the transistor reference chart and the allowable tolerances of the instrument.

Inter-element shorts of a transistor which are Emitter to Base, Base to Collector and Emitter to Collector, may be detected by the following reactions of the tester.

1. Base to Collector short will make the meter deflect off scale if an ICBO test is performed.
2. Emitter to Base short will have this effect - low or no IC reading with the IC control set to its maximum position. The IC control has little or no effect on the IC current.
3. Emitter to Collector short will show up as a high IC reading on the meter, which cannot be reduced with the IC control.

H. Circuit Limitations

As with all instruments, there are limitations to which they can be used. Therefore, this section will help the user of the instrument to overcome some of its pitfalls by altering the external circuitry of the transistor to be tested or by using a slightly different test procedure when required.

1. General

- a. While following the regular test procedure for an "In Circuit" test on a circuit which has a low external input impedance, it is possible that the transistor input resistance cannot be nulled out. Under these circumstances, it is necessary to increase the Collector current of the transistor under test in order to decrease its input resistance. The limitations to the above solution are the collector dissipation of the transistor under test and the shunting effects of the external input circuitry impedance.
- b. Also the maximum ratio of the transistor input resistance to the external input impedance which can be detected by the bridge circuit is 10 to 1. Therefore, under the lowest limit of external input impedance, 25 ohms, the maximum detectable value of the transistor input resistance is 250 ohms.
- c. There are external circuit conditions under which it is impossible to reverse bias the transistor under test when performing a Z Ohm Circuit test. This is due to extremely low values of self-biasing networks. When this condition exists, it is necessary to reduce the collector voltage to zero. This will reverse bias the transistor under test, and the external circuitry impedance can be measured as outlined above. After the Z Ohm Circuit test has been made, the Collector Volts switch should be returned to its previous position.
- d. In some special circuits, where the external input circuitry of the transistor being tested exhibits a large capacitance, .5 μ f or larger, across its base to emitter leads, it is necessary to disconnect one side of this capacitor before performing the tests.

2. Type of Circuits

Various types of circuits with their specific difficulties in testing them, as well as special techniques used to overcome these difficulties will be given in this section.

a. RF and IF stages

In some RF and IF AVC controlled stages, which have both the base and the low side of the collector tank heavily bypassed, it is possible, even under these adverse conditions that the Z Ohm Circuit potentiometers can still null out the external circuit impedance. However, the value of this impedance will be very low -- almost a short circuit, and when these circumstances exist, it is neces-

sary to open one side of these bypass condensers. This will remove the low impedance from the emitter-base circuit. Then the stage can be tested in the usual manner.

b. Audio driver stages

When testing an audio output driver stage of a radio, it is necessary to set the volume control to approximately $1/2$ of its maximum resistance. This will eliminate an AC short between the base and the emitter of the transistor being tested.

c. Detector Stage

Figure 9 shows a detector stage in which a slightly different test procedure is required. This procedure is to place the "Out of Circuit" switch to the "Out of Circuit" position, omit the Z Ohm Circuit test and then proceed to test the transistor as outlined above. From figure 9 one can see that the diode isn't conducting when the transistor is forward biased by the 1890. Therefore the Z Ohm

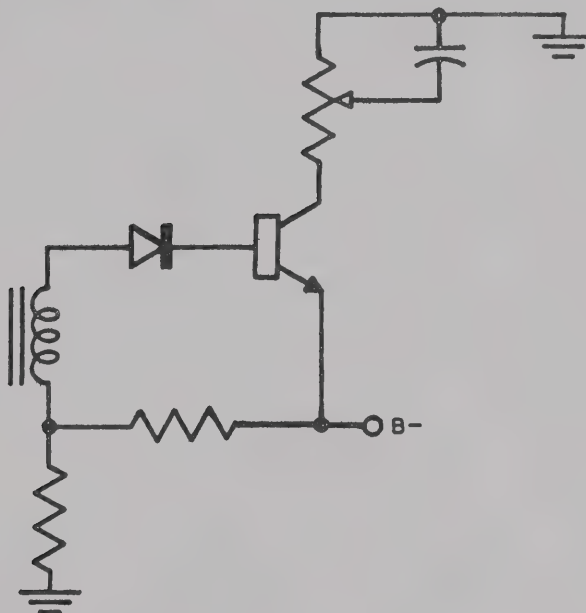


Figure 9.

Circuit test should be omitted because the Z Ohm Circuit test reverses the forward biasing voltage applied to the transistor under test and in this case it also makes the diode conduct, which produces an erroneous input impedance measurement.

d. Direct Coupled Circuits

Directly coupled PNP to NPN circuits require a slightly different test procedure. This procedure is to preset the Z Ohm Circuit potentiometers to the approxi-

mate value of the external input impedance. Then omit the Z Ohm Circuit Test and continue with the other tests. The reason for this deviation is that the Z Ohm Circuit Test reverse biases the transistor under test, however at the same time it acts as a collector supply voltage for the previous transistor, which then shunts the input impedance of the transistor under test.

e. Switching Circuits

When performing a Z Ohm Circuit Test on a Transformer Diode gate circuit or on a circuit which uses a diode to limit the reverse bias that can be applied to the emitter base junction, the following test procedure should be used: preset Z Ohm Circuit potentiometers and then omit the Z Ohm Circuit Test. The potentiometer setting will depend upon the circuitry involved. If the diode is conducting when the transistor is forward biased, the Z Ohm Circuit potentiometers should be set to the approximate value of the impedance between the base and emitter. Figure 10A shows such a circuit. If the diode is cut off when the transistor is forward biased, the Z Ohm Circuit Potentiometer should be set to the approximate value of impedance between base and emitter, in some cases an open circuit. If the latter is the case the "Out of Circuit" switch should be placed to the "Out of Circuit" position. Figure 10B shows a circuit in which the diode doesn't conduct when the transistor is forward biased and the external input impedance is determined by its biasing network and the impedance of the previous stage. If the above procedure is not followed an erroneous input impedance measurement will be obtained. This is due to the fact that the Z Ohm Circuit test reverses the forward biasing voltage of the transistor under test and at the same time it also reverses the voltage applied to the diode in the external circuitry which might cause it to conduct or to become cut off depending upon the polarity of the voltage. Therefore the circuitry should be checked before attempting to test the transistor.

A Schmitt trigger, Figure 11 is another circuit in which some difficulties may arise when checking the second transistor of the circuit. This is due to the forward biasing network of the 1890 which is used to adjust the collector current of the transistor under test and it can also act as a collector supply for the first transistor. This difficulty can be eliminated by placing a short between the collector and the emitter of the first transistor, and then proceed to test the second transistor as outlined above.

Figure 12 is a directly coupled monostable multivibrator. In order to test the three transistors of the circuit a few modifications have to be made. The first modification is to open lead B for all of the tests and then Q3 can be tested in the usual manner. If lead B is not opened when the tests on Q3 are performed, the collector voltage supply will be short circuited through the emitter base diode of Q2. When testing Q1 it is necessary to short the emitter and base of Q2 and when testing Q2 it is necessary to short the emitter and base of Q1. If this isn't done, one could mistake the leakage current I_{CEO} of the transistor not under test for a shorted or leaky transistor. Then test the transistors as outlined above.

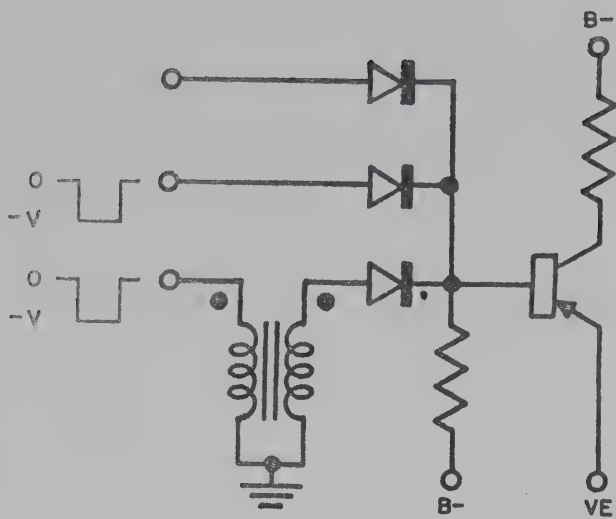


Figure 10A.

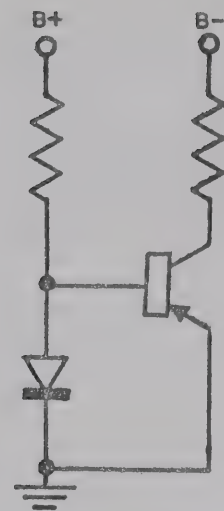


Figure 10B.

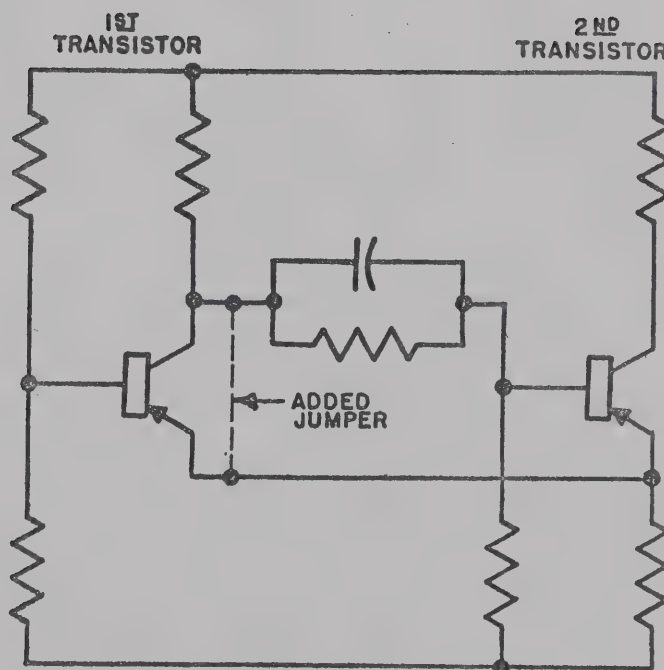


Figure 11.

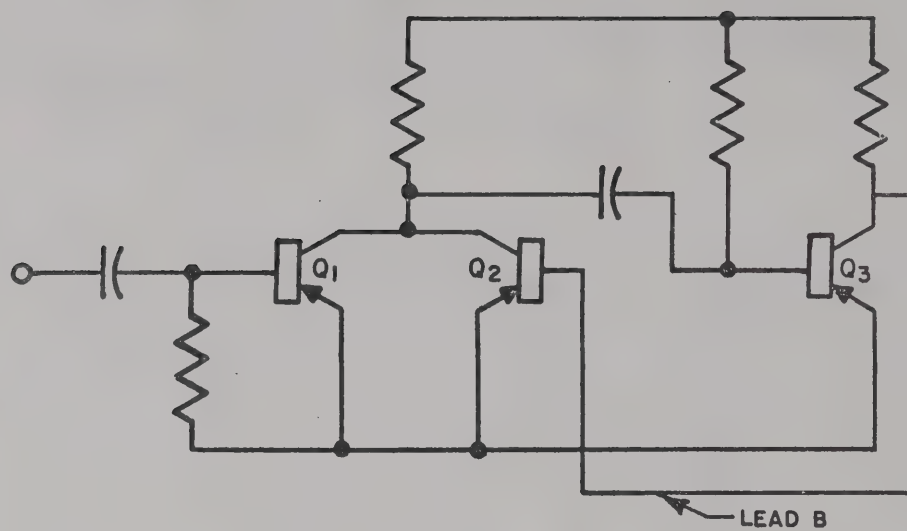


Figure 12.

MAINTENANCE

1. General Troubleshooting techniques.

The batteries should be checked periodically. To do this a Battery Test position has been incorporated into the unit.

a. Battery Test #1 - 22.5 volt battery.

Place the Function Selector Switch to the I_{CB}O position and turn the Operate Switch to the left. The meter should read in the green portion of the battery scale. If it reads in the red portion of the scale the battery is weak and should be replaced.

b. Battery Test #2 - 2, 4.5 Volt Batteries

Place the Function Selector switch to the I_C position and turn the Operate Switch to the left. The meter should read in the green portion of the battery scale. If it reads in the red portion of the scale the batteries are weak and should be replaced.

c. If the meter doesn't deflect at all, the following faults could have occurred.

1. The meter is open.
2. Both of the batteries are completely dead.
3. The cable assembly was not connected or has become loose.
4. The batteries have not been installed in the unit.

d. If the batteries are good, use Table 1 to check out the switching. This table shows where the various switches should be placed and what voltages are to be read at the binding posts of E-C, E-B and B-C. The plus lead of the DC voltmeter is indicated by a + sign over the pair of binding posts being measured.

e. The operation of the oscillator and amplifier can be checked out by the use of the resistance and voltage measurement chart, Table 2. Note: When making resistance measurements with an ohmmeter the lead with the positive potential is placed to ground. If this is not done meaningless data can be obtained.

2. Calibration

In general, the Model 1890, In Circuit Transistor Tester will give long uninterrupted service. However, for your convenience a complete calibration procedure will be given. The procedure will be divided into three sections -- Oscillator calibration, Amplifier calibration and setting the knobs of the Z Ohm Circuit and R_{IN} Transistor Potentiometers.

a. Oscillator Calibration

(1) The oscillator is calibrated in the following manner:

- (a) Rotate the Beta Cal potentiometer to its maximum position and check the DC voltages at the terminals of the transistors. Nominal values are listed in Table 2.
- (b) Then, using a general purpose scope, observe the output waveform of the oscillator. It should be a 1000 cps sine wave. In order to check the frequency, connect a 1000 cps oscillator to the horizontal amplifier of the scope;

make sure the scope's horizontal selector switch is in one of the horizontal positions. If the transistor oscillator is tuned to 1000 cps a single Lissajous pattern is obtained on the scope. If the oscillator is not properly tuned, vary the slug of L1 until a single Lissajous pattern is obtained. Then place the horizontal selector switch of the scope to the recurrent sweep position and measure the output voltage at the collector of Q101. The voltage should be approximately 11V P-P $\pm$ 1.3V. Also measure the voltage across the secondary winding of the transformer T1. The voltage should be approximately 1.4V P-P + .2V. If the voltage is low, decrease the value of R104 by paralleling it with a larger resistor. After this has been accomplished return the Beta Cal Potentiometer to its minimum position. Note: There should be no output voltage when the Beta Cal Potentiometer is in its minimum position.

b. Amplifier Calibration

- (1) Recheck the DC Voltages of the transistors. The nominal values are listed in Table 2.
- (2) Disconnect the shielded wire from the input of the amplifier and connect a precision divider consisting of a 20K, 1% resistor and a 10 ohm 1% resistor to a variable frequency oscillator. Also connect the input of the amplifier across the 10 ohm resistor. Set the frequency of the oscillator to 1000 cps and then using an accurate VTVM or scope, adjust the voltage across the precision divider to 1V P-P. This will give the amplifier a .5MV input signal.
- (3) Energize the unit and note the reading on the meter, then vary the frequency of the oscillator. If the meter doesn't peak at 1000 cps adjust the slug of L3 until it does peak at a 1000 cps. Then check the frequency response of the amplifier from 20 cps to approximately 200Kc. There should be only one peak and this should occur at 1000 cps. If the amplifier peaks at a low frequency, 150-400 cps, select a transistor for the second stage which will eliminate this condition. Note: The oscillator that is used for this test must have a good frequency response from 20 cps to approximately 200Kc.
- (4) Measure the AC voltage at the output of the 3rd stage of the amplifier with a scope. The peak to peak voltage should be within 14.5V P-P to 15.5V P-P which should be sufficient to drive the meter to full scale. If the output voltage is higher than 15.5V P-P adjust the negative feedback resistor R133, a 5K potentiometer, to a smaller value. If the output voltage is less than 14.5V P-P adjust the negative feedback resistor R133 to a larger value.
- (5) Check the DC voltage at the collector of the third stage, the voltage should be at least -10V DC. If it is less negative, increase the value of R141 from 220K to 270K and recheck this DC voltage.
- (6) With an output voltage of 14.5V P-P to 15.5V P-P, check the waveform. The waveform should not be clipped or bottomed. If the wave is distorted readjust the forward biasing resistor R141. Don't adjust R142 below 10K because this will load the second stage and shunt the input of the third stage.
- (7) If all the preceeding requirements are met and the meter is still reading low, decrease the value of R146 in the metering circuit by paralleling it with another resistor, however, the total parallel resistance should not be less than 86K. If the meter still reads low, check the diodes in the bridge circuit. After adjusting the value of R146, the meter should be within $\pm$ 2% of full scale.

- c. Setting the knobs of the Z Ohms Circuit and R_{IN} TRANSISTOR potentiometer is accomplished in the following manner:

(1) Z Ohm Circuit knobs.

(a) Large knob of the Z Ohms Circuit potentiometer

1. Place a 10K, 1% resistor between the E and B leads of the test cable.
2. Set the Function Selector Switch to the Z Ohm Circuit position.
3. Place the Out of Circuit Switch to the In-Circuit position. This switch is ganged to the shaft of the 500 ohm potentiometer of the Z Ohm Circuit potentiometer. Be sure to set this potentiometer to its minimum position.
4. Place the Circuit Impedance Switch to the Normal position.
5. Turn the Operate Switch to the right and increase the signal by turning the Beta Cal potentiometer until the meter reads approximately 1/2 scale.
6. Vary the Z Ohm potentiometer outer shaft only, until a null is indicated.
7. Release the Operate Switch and set the indicator line of the knob to the 10K point on the inner dial of the Z Ohms Circuit potentiometers. Then tighten the knob.

(b) Small knob of the Z Ohms Circuit potentiometer.

1. Set the large knob of the Z Ohms Circuit potentiometer to its minimum position.
2. Place a 200 ohm, 1% resistor between E and B leads of the test cable.
3. Leave the Function Selector Switch in the Z Ohms Circuit position.
4. Turn the Operate Switch to the right and increase the signal by turning the Beta Cal potentiometer until the meter reads approximately 1/2 scale.
5. Vary the small knob of the Z Ohms Circuit potentiometer until a null is indicated on the meter.
6. Release the Operate Switch and set the indicator line of the knob to the 200 ohm point on the outer dial of the Z Ohms Circuit potentiometer. Then tighten the knob.

(2) R_{IN} TRANSISTOR Knob

- (a) Place the Function Selector Switch to the R_{IN} TRANSISTOR position.
- (b) Set the "Out of Circuit" Switch to the "Out of Circuit" position.
- (c) Place a 1K, 1% resistor between the E and B leads of the test cable.
- (d) Turn the Operate Switch to the right and increase the signal by turning the Beta Cal potentiometer until the meter reads approximately 1/2 scale.
- (e) Vary the R_{IN} TRANSISTOR potentiometer until a null is indicated on the meter.

- (f) Release the Operate Switch and set the indicator line of the knob to the 1K point on the dial of the R_{IN} TRANSISTOR potentiometer. Then tighten the knob.

(3) Final Check

Using the Model 1890, make an Out of Circuit measure on a transistor and note its beta. Then place the same transistor in a functionable circuit and make an In-Circuit beta measurement. Then compare the beta readings. They should be within $\pm 5\%$. Compare these beta readings to the listed betas in the Transistor Reference Chart or to the Transistor Manufacturer's literature. If the above test is satisfactory, it can be assumed that the tester is working properly.

ROW I	Circuit Impedance	Type Selector Position	Collector Volts Position	Ic Control Position	FUNCTION SELECTOR SWITCH																	
					Icbo			Ic			Z Ohms			R In			Beta Cal			Beta		
					+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	
					B-C	E-C	E-B	B-C	E-C	E-B	B-C	E-C	E-B	B-C	E-C	E-B	B-C	E-C	E-B	B-C	E-C	E-B
Normal		PNP	0	Min	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Normal		PNP	1.5	Min	+1.5	0	0	+1.5	0	+1.5	+1.5	0	+1.5	+1.5	0	+1.5	+1.5	0	+1.5	+1.5	0	0
Normal		PNP	3.0	Min	+3.0	0	0	+3.0	0	+3.0	+3.0	0	+3.0	+3.0	0	+3.0	+3.0	0	+3.0	+3.0	0	0
Normal		PNP	4.5	Min	+4.5	0	0	+4.5	0	+4.5	+4.5	0	+4.5	+4.5	0	+4.5	+4.5	0	+4.5	+4.5	0	0
Normal		PNP	0	Min-Max	0	0	0	-1.5	0	-1.5	0	0	-1.5	-1.5	0	+1.5	-1.5	0	+1.5	-1.5	0	+1.5
Low		PNP	0	Min-Max	0	0	0	-4.5	0	+4.5	+4.5	0	-4.5	-4.5	0	+4.5	-4.5	0	+4.5	-4.5	0	+4.5
ROW II					+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	
					B-C	E-C	E-B	B-C	E-C	E-B	B-C	E-C	E-B	B-C	E-C	E-B	B-C	E-C	E-B	B-C	E-C	
	Normal	NPN	0	Min	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
	Normal	NPN	1.5	Min	+1.5	0	0	+1.5	0	+1.5	+1.5	0	+1.5	+1.5	0	+1.5	+1.5	0	+1.5	+1.5	0	
	Normal	NPN	3.0	Min	+3.0	0	0	+3.0	0	+3.0	+3.0	0	+3.0	+3.0	0	+3.0	+3.0	0	+3.0	+3.0	0	
	Normal	NPN	4.5	Min	+4.5	0	0	+4.5	0	+4.5	+4.5	0	+4.5	+4.5	0	+4.5	+4.5	0	+4.5	+4.5	0	
	Normal	NPN	0	Min-Max	0	0	0	-1.5	0	+1.5	+1.5	0	-1.5	-1.5	0	+1.5	-1.5	0	+1.5	-1.5	0	
Low		NPN	0	Min-Max	0	0	0	-4.5	0	+4.5	+4.5	0	-4.5	-4.5	0	+4.5	-4.5	0	+4.5	-4.5	0	
ROW III					+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	
					B-C	E-C	E-B	B-C	E-C	E-B	B-C	E-C	E-B	B-C	E-C	E-B	B-C	E-C	E-B	B-C	E-C	
	Normal	Diode	0	Min	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
	Normal	Diode	1.5	Min	+1.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
	Normal	Diode	3.0	Min	+3.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
	Normal	Diode	4.5	Min	+4.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
	Normal	Diode	0	Min-Max	0	0	0	-1.5	0	+1.5	+1.5	0	-1.5	-1.5	0	+1.5	-1.5	0	+1.5	-1.5	0	
Low		Diode	0	Min-Max	0	0	0	-4.5	0	+4.5	+4.5	0	-4.5	-4.5	0	+4.5	-4.5	0	+4.5	-4.5	0	

TABLE 1

SYM. NO.	TYPE	EMITTER	BASE	COLLECTOR
Q101	2N651A	10K	1800 Ω	3800 Ω
		4.2 VDC	3.9 VDC	20.9 VDC
		.75 V PP		11 V PP
Q102	2N651A	10K	2700 Ω	3800 Ω
		4 VDC	4.1 VDC	20.9 VDC
		3.1 V PP	3.1 V PP	
		100 Ω	300 Ω	1600 Ω
Q103	2N650A	.15 VDC	.3 VDC	2.9 VDC
				.018 V PP
Q104	2N651A	3000 Ω	1600 Ω	3800 Ω
		2.8 VDC	2.9 VDC	22.5 VDC
		.012 V PP	.018 V PP	.13 V PP
Q105	2N651A	900 Ω	1100 Ω	12 K
		.92 VDC	.92 VDC	12.5 VDC
		.025 V PP	.094 V PP	14.5 V PP

TABLE 2

All resistance measurements were made with a Model 456 Multimeter.
The common lead to gnd.

All D. C. Voltage measurements were made with respect to gnd.

Likewise all scope readings were made with respect to gnd.

PARTS LIST

Symbol No.	Part No.	Description
	2360-96 and 97	BINDING POST: blue, Superior Electronic DF31BLC
	2360-99 and 100	BINDING POST: green, Superior Electronic DF31GNC
	2360-102 and 103	BINDING POST: yellow, Superior Electronic DF31YC
C101	3105-293	CAPACITOR: fixed, paper, 1 μ f, 10%, 50VDC Astron #MQZFP.5-1M-10
C102	3105-294	CAPACITOR: fixed, paper, 2 μ f, 10%, 50VDC Astron #MQZFP.5-2M-10
C103	3105-290	CAPACITOR: fixed, paper, .22 μ f, 10%, 100VDC CP05AIEB224K
C104	3105-287	CAPACITOR: fixed, paper .1 μ f, 10%, 100VDC CP05AIEB104K
C105A and B	3085-136	CAPACITOR: fixed, electrolytic, 100 μ f, 15 w V Sprague TE1162
C106	3085-135	CAPACITOR: fixed, electrolytic, 100 μ f, 50VDC Mallory #BSX-5100 or equiv.
C107	3105-289	CAPACITOR: fixed, paper, .47 μ f, 10%, 100V CP05AIEB474K
C108	3085-113	CAPACITOR: fixed, electrolytic, 25 μ f, 25 volts C.D. #NLW-25-25
C109	3105-290	CAPACITOR: fixed, paper, .22 μ f, 10%, 100V CP05AIEB224K
C110	3105-288	CAPACITOR: fixed, paper, .047 μ f, 10%, 200V CP05AIEC473K
C111	3105-259	CAPACITOR: fixed, paper, .01 μ f, 10%, 400V CP05AIEE103K
C112	3085-112	CAPACITOR: fixed, electrolytic, 30 μ f, 25 Volts C.D. #NLW-30-25
	3145-559	CASE
CR101	3870-41	SILICON DIODE: SD91, International Rectifier #SD91
CR102	3870-37	GERMANIUM DIODE: GE 1N91
CR103-106	3870-60	GERMANIUM DIODE: JAN 1N198
J101	3475-113	CONNECTOR: female, MI-14F U.S. Component

PARTS LIST

Symbol No.	Part No.	Description
L101	3250-82	CHOKE: Variductor TVC4 UTC
L102	3250-84	CHOKE: 10 Hy, 10 ma, 135 ohms, UTC
L103	3250-83	CHOKE: Variductor HVC-4 UTC
P101	3475-114	CONNECTOR: male, MI-14M U. S. Component
R101	18411-222	RESISTOR, fixed, composition: 220 ohms, 10%, 1/2 watt, MIL type RC20GF221K per MIL-R-11. Allen Bradley part #EB2211
R102	18413-182	RESISTOR, fixed, composition: 18,000 ohms, 10%, 1/2 watt, MIL type RC20GF183K, per MIL-R-11. Allen Bradley part #EB1831
R103	18412-392	RESISTOR, fixed, composition: 3900 ohms, 10%, 1/2 watt, MIL type RC20GF392K per MIL-R-11. Allen Bradley part #EB3921
R104	18413-102	RESISTOR, fixed, composition: 10,000 ohms, 10%, 1/2 watt, MIL type RC20GF103K, per MIL-R-11. Allen Bradley part #EB1031
R105	18411-102	RESISTOR, fixed, composition: 100 ohms, 10%, 1/2 watt, MIL type RC20GF101K per MIL-R-11. Allen Bradley part #EB1011
R106	18413-392	RESISTOR, fixed, composition: 39,000 ohms, 10%, 1/2 watt, MIL type RC20GF393K per MIL-R-11. Allen Bradley part #EB3931
R107		Same as R104
R108, 110	16925-391	RESISTOR, variable: 10K ohms, 10%, 2 watt, Z taper, 3/8-32 x 3/8 bushing, 3/4 shaft FMS. Clarostat 53C1 (per MIL-R-94B, style RV4)
R109, 111	16925-393	RESISTOR, variable: concentric, front section 100K ohms, 10%, Z taper; rear section 500 ohms, 10%, linear taper with SPST switch 3/8-32 bushing x 3/8 long. Outer shaft 3/4", inner shaft 1-1/4" FMS, Clarostat D53S, 2W (per MIL-R-94)
R112	18551-32	RESISTOR, fixed film: 49.9 ohms, 1%, 1/2 watt, MIL type RN70B49R9F per MIL-R-10509
R113	18411-472	RESISTOR, fixed composition: 470 ohms, 10%, 1/2 watt, MIL type RC20GF471K per MIL-R-11. Allen Bradley part #EB4711.
R114	18550-173	RESISTOR, fixed composition: 4.7 ohms, 10%, 1 watt. MIL type RC32GF4R7K per MIL-R-11. Allen Bradley part #GB47G1.

PARTS LIST

Symbol No.	Part No.	Description
R115	18410-472	RESISTOR, fixed composition: 47 ohm, 10%, 1/2 watt MIL type RC20GF470K per MIL-R-11 Allen Bradley part #EB4701
R116		Same as R113
R117	18412-472	RESISTOR, fixed con position: 4700 ohms, 10%, 1/2 watt. MIL type RC20GF472K per MIL-R-11. Allen Bradley part #EB4721
R118	18687-201	RESISTOR, fixed wirewound: 1 ohm, 1%, .15 watt MIL type RB55AE1R000F per MIL-R-93
R119	18687-206	RESISTOR, fixed wirewound: 10.05 ohms, 1%, .15 watts, MIL type RB55AE10R05F per MIL-R-93
R120	18687-217	RESISTOR, fixed wirewound: 105.3 ohms, 1%, .15 watt MIL type RB55AE105R3F per MIL-R-93
R121	18687-220	RESISTOR, fixed wirewound: 222.2 ohms, 1%, .15 watt MIL type RB55AE222R2F per MIL-R-93
R122	18687-208	RESISTOR, fixed wirewound: 20.20 ohms, 1%, .15 watt MIL type RB55AE20R20F per MIL-R-93
R123		Same as R117
R124	40600-251	RESISTOR, variable: 250 ohms, 10%, 2 watt, screw- driver slot, 3/8" bushing length, 7/8" shaft FMS, MIL type RV4NAYSD251A per MIL-R-94 Allen Bradley type J
R125	18412-332	RESISTOR, fixed composition: 3300 ohms, 10%, 1/2 watt MIL type RC20GF332K per MIL-R-11 Allen Bradley part #EB3321
R126	18551-35	RESISTOR, fixed film: 499K ohms, 1%, 1/2 watt MIL type RN70B4993F per MIL-R-10509
R127	18551-31	RESISTOR, fixed film: 1000 ohms, 1%, 1/2 watt MIL type RN70B1001F per MIL-R-10509
R128	18687-205	RESISTOR, fixed wirewound: 10 ohm, 1%, .15 watt MIL type RB55AE10R00F per MIL-R-93
R129		Same as R127
R130		Same as R128
R131		Same as R118
R132	18551-34	RESISTOR, fixed film: 200K ohms, 1%, 1/2 watt MIL type RN70B2003F per MIL-R-10509

PARTS LIST

Symbol No.	Part No.	Description
R133	16925-392	RESISTOR, variable: 5K ohms, 1/4 watt, Centralab 20-9316 with Solder Lugs
R134		Same as R102
R135		Same as R105
R136	18410-152	RESISTOR, fixed composition: 15 ohms, 10%, 1/2 watt MIL type RC20GF150K per MIL-R-11 Allen Bradley part #EB1501
R137	18413-911	RESISTOR, fixed composition: 91K ohms, 5%, 1/2 watt MIL type RC20GF913J per MIL-R-11 Allen Bradley part #EB9135
R138	18410-682	RESISTOR, fixed composition: 68 ohms, 10%, 1/2 watt MIL type RC20GF680K per MIL-R-11 Allen Bradley part #EB6801
R139		Same as R125
R140	18413-222	RESISTOR, fixed composition: 22,000 ohms, 10% 1/2 watt, MIL type RC20GF223K per MIL-R-11 Allen Bradley part EB2231
R141	18414-222	RESISTOR, fixed composition: 220K ohms, 10%, 1/2 watt MIL type RC20GF224K per MIL-R-11 Allen Bradley part #EB2241
R142		Same as R104
R143		Same as R104
R144	18412-102	RESISTOR, fixed composition: 1000 ohms, 10% 1/2 watt, MIL type RC20GF102K per MIL-R-11 Allen Bradley part #EB1021
R145		Same as R136
R146		Same as R137
	19350-361	SOCKET: transistor, mica filled, Beryllium copper silver pl. contacts, gold flashed, Elco #3301 with flat saddle
S101	19912-467	SWITCH, rotary: 3 section, 3 position, spring loaded in both directions, 3/8" bushing length, 7/8" shaft FMS per MIL-S-3786 (BATT. TEST - OFF - OPERATE)
S102	19912-456	SWITCH, rotary, 3 section, 3 position, 3/8" bushing length, 7/8" shaft, FMS, Oak type F per MIL-S-3786 (Type Selector)

PARTS LIST

Symbol No.	Part No.	Description
S103	19912-458	SWITCH: rotary, 1 section, 4 position, 3/8 bushing length, 7/8" shaft FMS, Oak type F per MIL-S-3786 (Collector Volts)
S104	19912-457	SWITCH: rotary, 6 sections, 6 position, 3/8 bushing length, 7/8 shaft FMS, Oak type F per MIL-S-3786 (Function Selector)
S105	19912-455	SWITCH: dual concentric, front section, 1 section 3 position; rear section, 1 section, 2 position per MIL-S-3786 (Circuit Impedance)
T101	20800-152	TRANSFORMER: driver 10-12K prim. to 2-2.5K sec. type TF4RX13YY, DO-T11 UTC per MIL-T-27
Q101	20861-14	TRANSISTOR: 2N651A Motorola
Q102		Same as Q101
Q103	20861-13	TRANSISTOR: 2N650A Motorola
Q104		Same as Q101
Q105		Same as Q101

PARTS LIST

Symbol No.	Part No.	Description
S103	19912-458	SWITCH: rotary, 1 section, 4 position, 3/8 bushing length, 7/8" shaft FMS, Oak type F per MIL-S-3786 (Collector Volts)
S104	19912-457	SWITCH: rotary, 6 sections, 6 position, 3/8 bushing length, 7/8 shaft FMS, Oak type F per MIL-S-3786 (Function Selector)
S105	19912-455	SWITCH: dual concentric, front section, 1 section 3 position; rear section, 1 section, 2 position per MIL-S-3786 (Circuit Impedance)
T101	20800-152	TRANSFORMER: driver 10-12K prim. to 2-2.5K sec. type TF4RX13YY, DO-T11 UTC per MIL-T-27
Q101	20861-14	TRANSISTOR: 2N651A Motorola
Q102		Same as Q101
Q103	20861-13	TRANSISTOR: 2N650A Motorola
Q104		Same as Q101
Q105		Same as Q101

